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ERCP SIMULATION REFINEMENT

FINAL REPORT

Deliverable Item #1 on
Georgia Tech Project B-03-636

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Prepared for:

Department of Medicine
The Medical College of Georgia
Augusta, Georgia 30912

Prepared by:

Biomedical Interactive Technology Center
Georgia Institute of Technology
Atlanta, Georgia 30332-0200

ERCP SIMULATION REFINEMENT

Summary

The Georgia Institute of Technology and the Medical College of Georgia have developed a prototype computer simulation for Endoscopic Retrograde Cholangiopancreatography (ERCP). The primary objective for this simulation is to improve the ERCP skills training. The Biomedical Interactive Technology Center submits this final letter report to summarize the efforts that were performed on GIT Project B-03-636 to refine the GIT/MCG ERCP during the performance period of July 1, 1997 through March 31, 1998.

Background

ERCP is a minimally invasive technique for evaluating and treating pathologic conditions of the biliary and pancreatic ducts. The major benefit of ERCP is that it allows patients to avoid more invasive surgical or radiological procedures, and the therapeutic applications of ERCP significantly lower the risk of infection, speed recovery time, and reduce the cost of delivering care. However, while ERCP provides the patient with substantial advantages over traditional methods, ERCP requires advanced skills and extensive experience to minimize the risk of complications. The Georgia Institute of Technology and the Medical College of Georgia have developed a research prototype of an interactive computer simulation of ERCP. The primary objective for this computer simulation is to improve training of ERCP skills. The simulator consists of several physical components and several "virtual" or computer generated components. The physical components form the interface through which the physician performs the procedure in the simulated environment. The simulated session begins as an endoscope is inserted through the "mouth" of the simulator. The endoscope is guided into position using standard endoscopic techniques. Two display options are provided: the view that would be seen through the optics on the endoscope, and a view of the endoscope in relation to the surrounding anatomy. The second view is not available in real life, but this view may help training physicians to better understand the 3D geometry and positioning maneuvers. Both views are computer-generated imagery of the virtual anatomy. The stomach, duodenum, and papilla are represented by three-dimensional computer models that are texture mapped with photographic images of the anatomy acquired during endoscopic examinations.

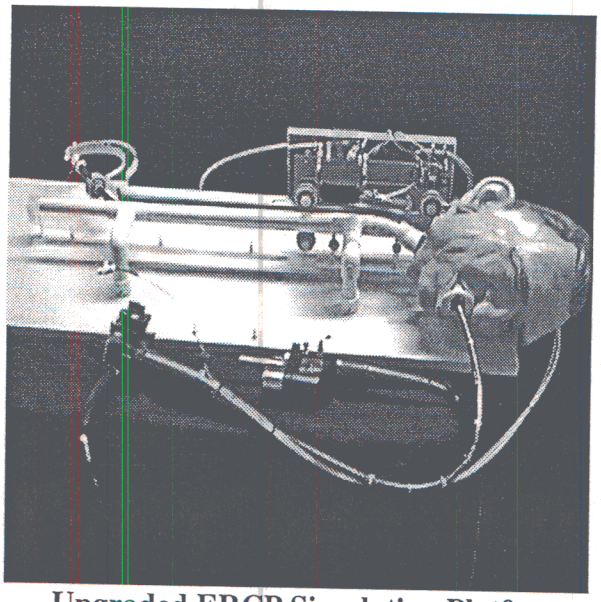
Computer simulation may one day be as useful for skills training in gastrointestinal endoscopy as it has proven to be in flight training for pilots. Simulators could be used to "pre-train" Gastroenterology trainees beginning to learn endoscopy, allowing them to develop the needed motor skills to efficiently manipulate the endoscope and to recognize both normal anatomy and pathologic conditions before performing endoscopy on actual patients. Computer simulated endoscopy also offers the opportunity to standardize certification of endoscopic skills. Standard and repeatable methods for skills certification may become the most important application for medical simulation technology. Simulation could also provide a means of disseminating new procedural skills training to experience endoscopists. Adapting a simulator to allow practice of new techniques is certainly preferable to exposing patients to the physicians learning curve (a lesson we should have learned from the high number of bile duct injuries occurring during the learning phase of surgeons adapting to the technique of laparoscopic cholecystectomy).

ERCP Refinements

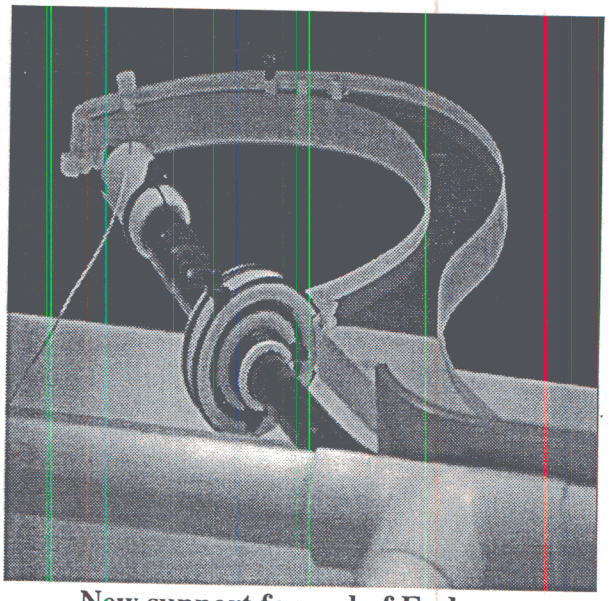
During the period of performance, Georgia Tech focussed on efforts to refine the ERCP simulator. The efforts were divided between upgrading the simulation platform, adding new detail to the anatomical models, and creating new software tools to work on a less expensive computer platform.

Upgrading the ERCP simulation platform

A new ERCP simulation platform was created during this project to address the limitations of the force feedback and user interaction in the original prototype. Several of the "loose" components in the original design were replaced by more sturdy Plexiglas and aluminum components to smooth and steady the movements of the endoscope. The new ERCP simulation platform provides more stable advancing of the endoscope and it holds the position steady when the advancing is stopped. In the original prototype, the endoscope could slide without resistance along the track, and this created an unrealistic movement during the final steps of selective cannulation. In the actual procedure, the anatomy of the GI tract tends to hold the endoscope in place, and this resistance should be represented during a training session. The new simulation platform addresses this limitation in the first prototype. The figures below show the new platform:

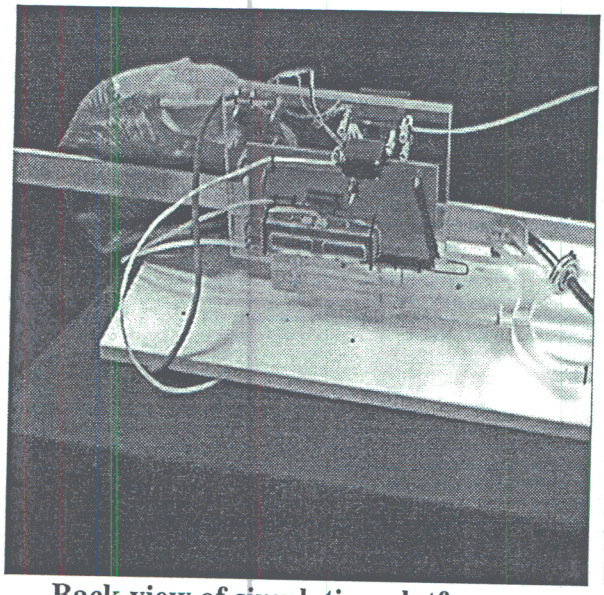


Upgraded ERCP Simulation Platform

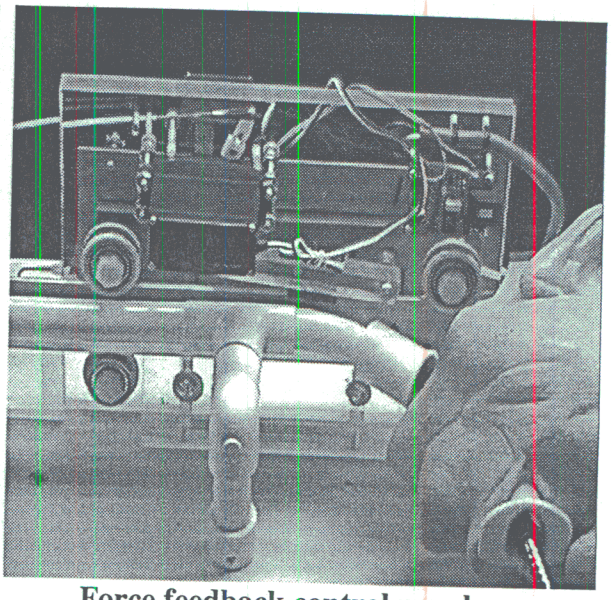


New support for end of Endoscope

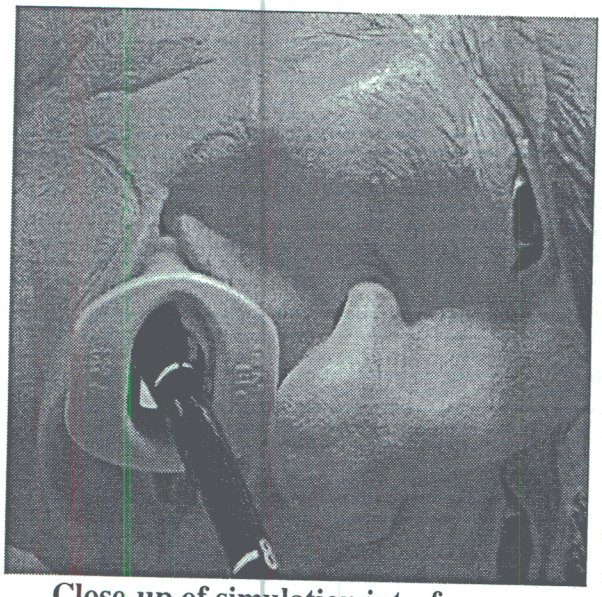
The new ERCP simulation platform also includes the capability for stopping the endoscope advance with a braking mechanism, as if it had run into a barrier. This braking has not been fully integrated into the software environment, but the platform is designed to accept software commands to restrict the advancement of the endoscope. The new platform also provides an upgraded force feedback system that has been mounted on a thick Plexiglas plate.



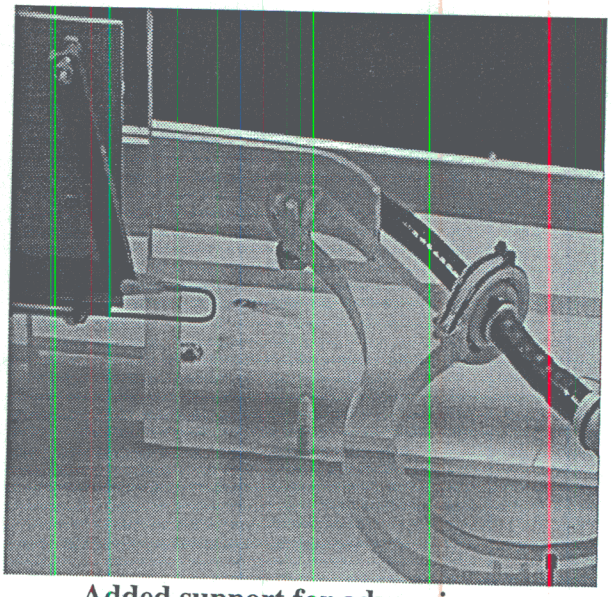
Back view of simulation platform



Force feedback control panel



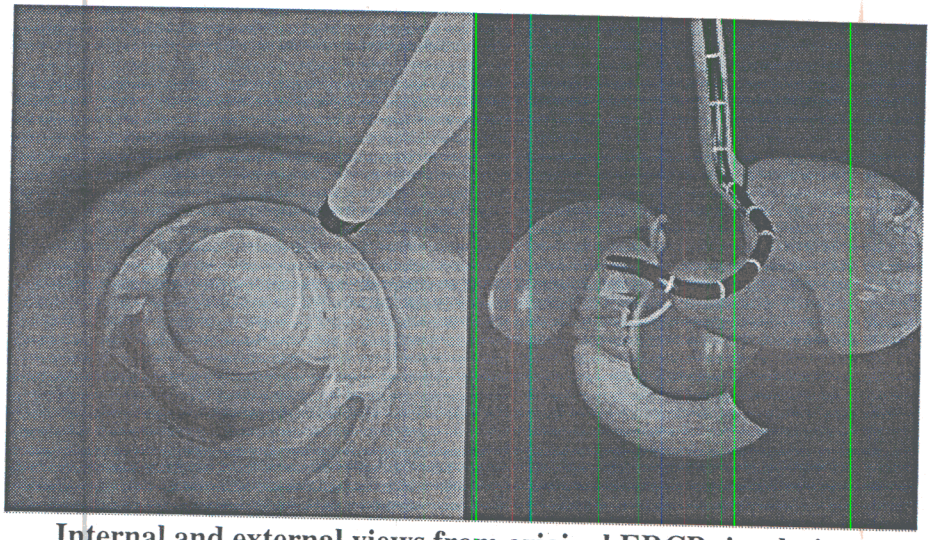
Close-up of simulation interface



Added support for advancing scope

New details in anatomical representation

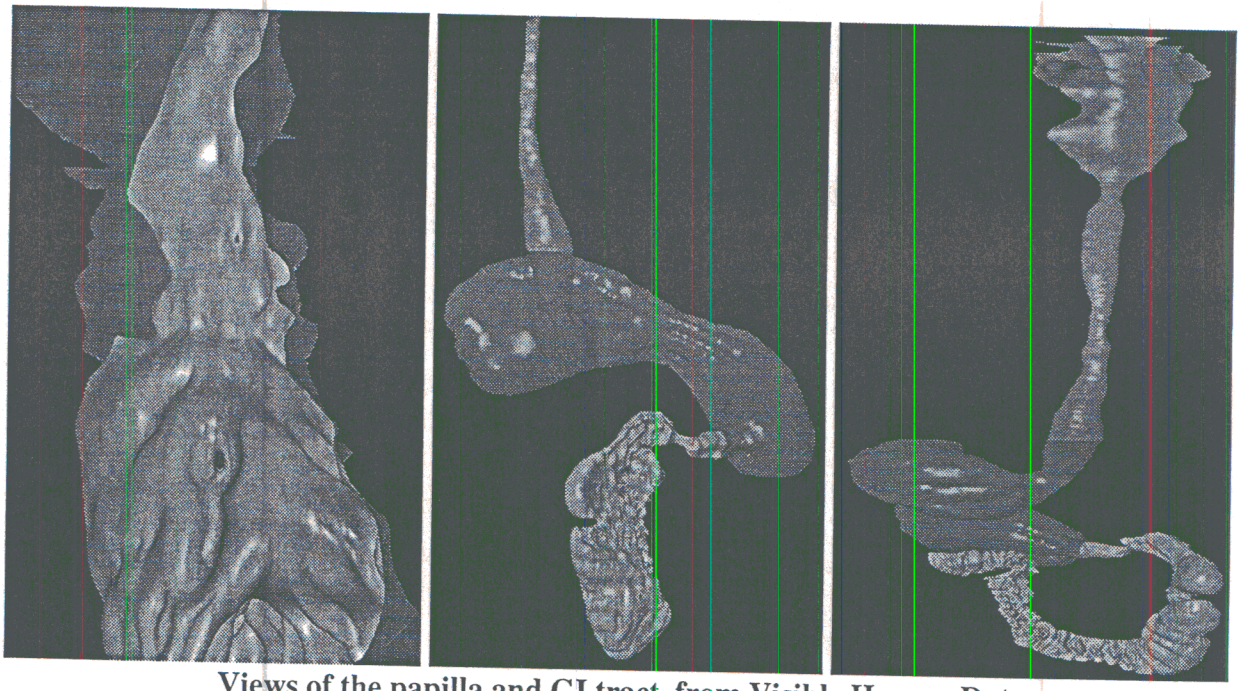
The anatomical representation in the original prototype included simple models of the anatomy with a texture mapped pattern extracted from a videotaped endoscopic session. The models from the original ERCP simulation are displayed in the figure below:



Internal and external views from original ERCP simulation.

During this project, efforts were made to improve the realism of the three-dimensional anatomy. As part of this effort, Georgia Tech acquired an anatomical data set from the National Library of Medicine's Visible Human project with special modifications for the ERCP simulation provided by Visible Productions. These models were produced at different levels of detail to support the various performance levels of different simulation platforms. High-resolution models can only be rendered on a high end - and expensive - 3D graphics workstations, but lower resolution data sets can be displayed and possibly manipulated on lower cost PC platforms.

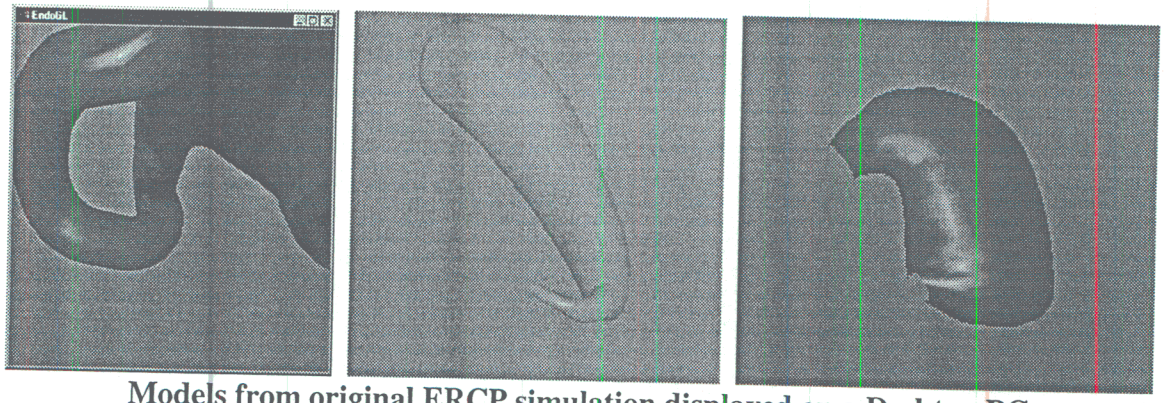
The figures below display the anatomy from the Visible Human data set. These models provide a more detailed and realistic representation of the anatomy. However, additional modifications are needed to make this data part of the interactive simulation.



Views of the papilla and GI tract from Visible Human Data

Software modifications for PC platform

During the project, efforts were also directed toward developing display and simulation capabilities on a microcomputer platform. The original ERCP simulation prototype was developed using an expensive ($150K) Silicon Graphics Onyx 3D graphics super computer. The software was written in SGI's "GL" programming language, but it could not be directly converted to another type of computer. Under this project, new software tools were created to read in the anatomical models for the ERCP simulation and display them in real time on a PC platform using Microsoft's free OpenGL software. The figures below illustrate the 3D rendering under OpenGL of a few of the anatomical components from the original prototype:



Models from original ERCP simulation displayed on a Desktop PC

The PC program runs under the Microsoft operating system on a standard Pentium computer. The application allows the user to rotate and zoom in on the models with a mouse control. An objective for this approach was to make the ERCP simulation work on a lower cost PC platform in the same way that it worked on the SGI computer platform, but this turned out to be more difficult than originally estimated. However, the performance to cost ratio continues to dramatically improve each year in the rapidly advancing consumer computer market, and a full range of interactive simulation capabilities can soon be supported on a cost effective platform. The importance of this direction was underlined when the Silicon Graphics Onyx computer used in the original prototype experienced a hardware failure. The high performance SGI from 1994 now costs more to repair than it would cost to purchase a brand new simulation workstation with very similar processing capabilities.

Summary

During the performance period, Georgia Tech worked with the Medical College of Georgia to upgrade the ERCP Simulation. These efforts included new software development, a redesign of the simulation platform, and 3D graphics tools for displaying ERCP models on a low cost microcomputer platform.